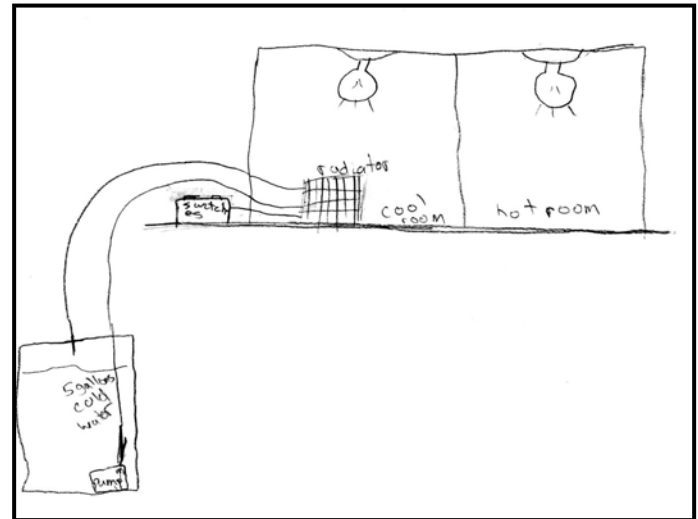
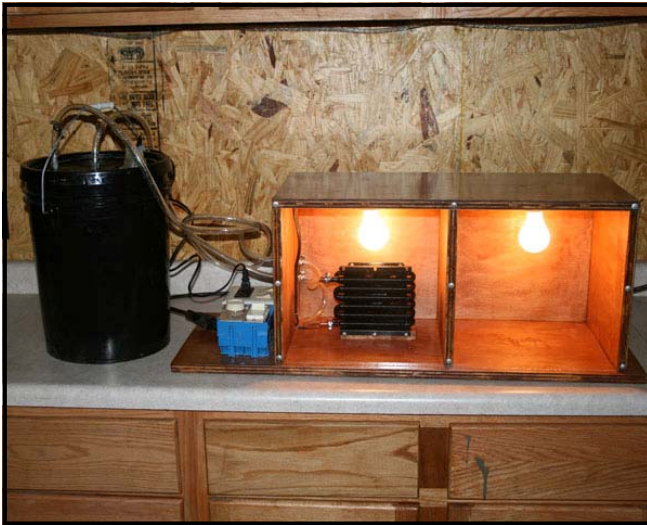
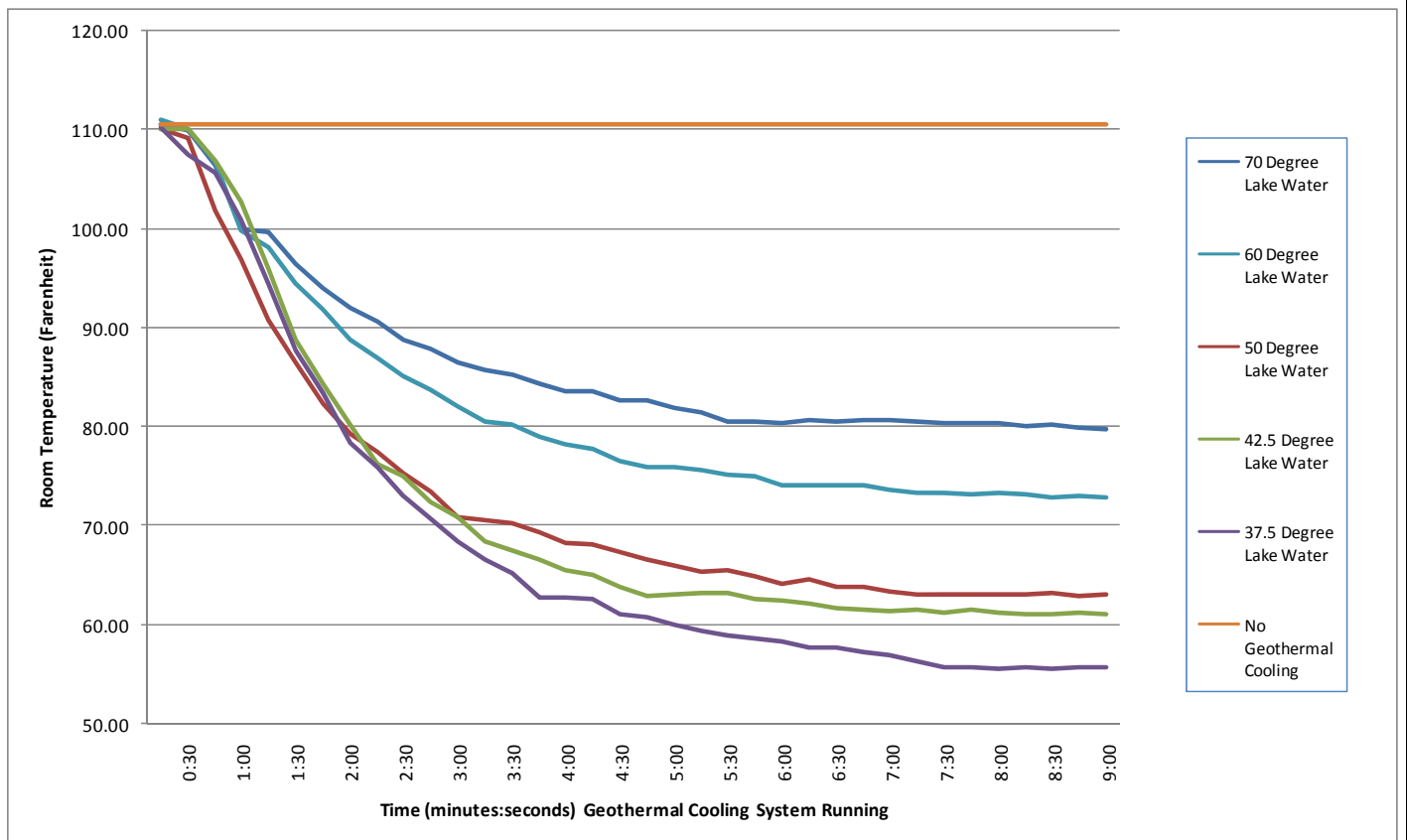


Geothermal Cooling System



Lake Water Temperature Impact On Cooling





Scientific Question:

What effect does the depth of incoming lake water have on the efficiency of a geothermal cooling system?



Hypothesis:

If the intake water comes from a deeper depth, then the circulated water will be cooler and this will lower the temperature in the geothermal system room.

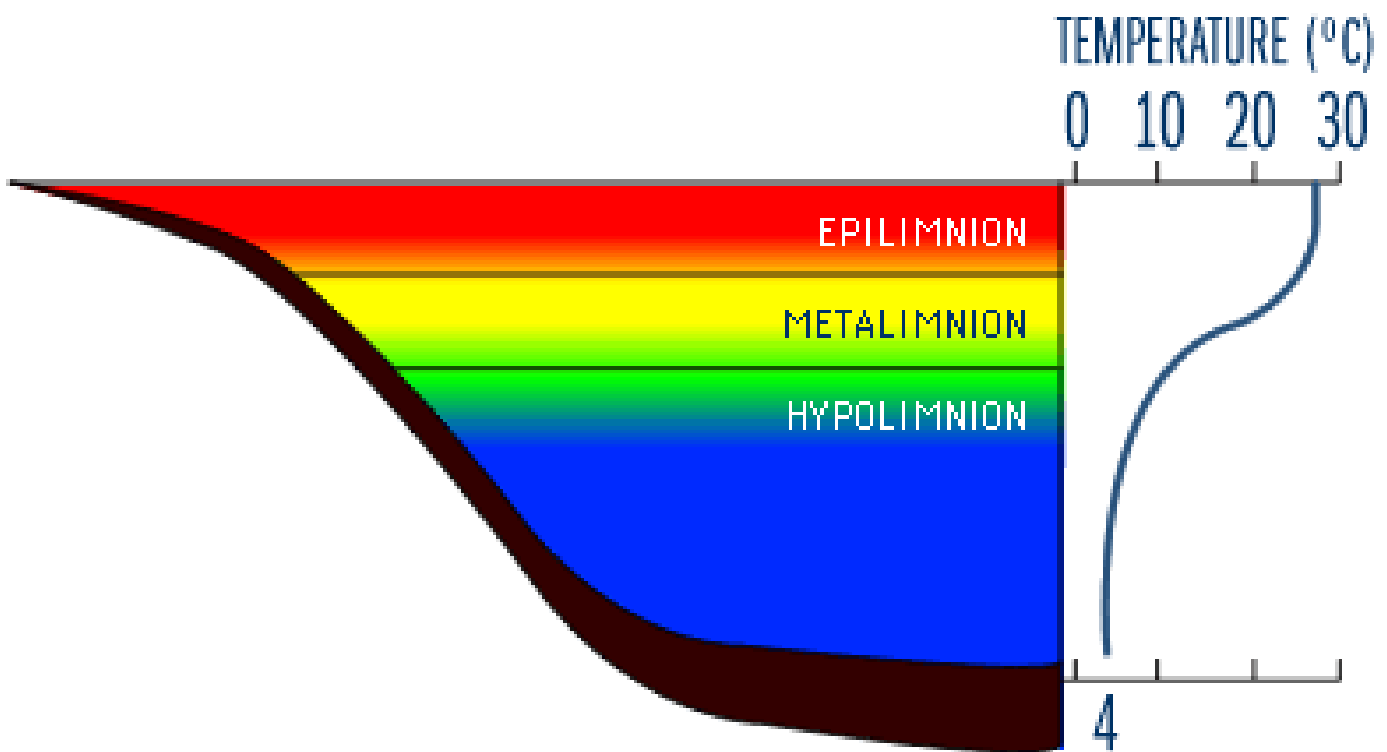


Material List:

1. Plexiglass
2. $\frac{3}{4}$ inch plywood
3. Electrical switches
4. Electrical boxes
5. Electrical wire
6. Extension cord
7. Light Sockets
8. Light bulbs
9. Aquarium pump
10. Drill and bits
11. Screw driver
12. Computer liquid cooling fan/radiator
13. Plastic tubing
14. Hose clamps
15. Hose connectors
16. Water
17. Ice
18. 5 Gallon Container
19. Thermometers
20. Display Board
21. Computer
22. Printer
23. Tape measure
24. Wood stain
25. Urethane
26. Screws
27. Table saw

Thermal Stratification

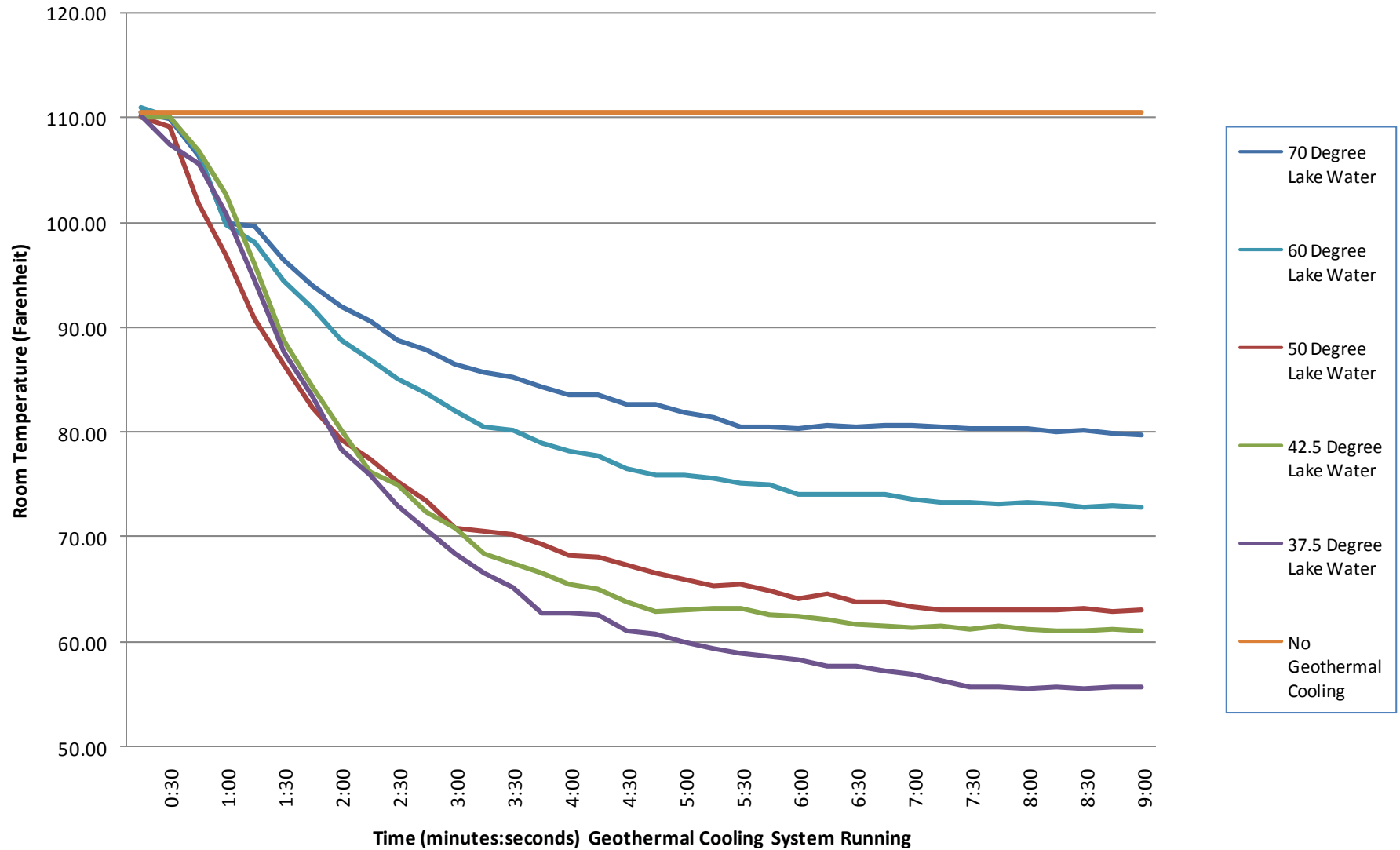
Thermal stratification is common in deep lakes and can be used to create a geothermal cooling system. The temperature of the lake changes with depth of the water. Warmer water is near the surface and colder water is near the bottom.



- 1. Draw out a sketch of the geothermal cooling system on paper. When drawing is mostly complete transfer to a computer to help with accuracy and presentation.**
- 2. Create a material list and then gather materials.**
- 3. Build the frame of the geothermal cooling system.**
- 4. Cut plexiglass piece for the front of the system.**
- 5. Screw the radiator in on a wooden base.**
- 6. Drill holes and insert the water tube connectors.**
- 7. Install one light in each room.**
- 8. Hook up electrical wires and switches for the lights, radiator fan, and the pump.**
- 9. Cut a hole in the five gallon water jug and insert pump and water temperature probe.**
- 10. Drill holes for the water connectors in the water jug.**
- 11. Hook up hoses from the pump to the top of the water jug and from the water jug to the radiator.**

- 12. Screw the plexiglass window on the front of the geothermal cooling system and seal edge with tape.**
- 13. Fill the water jug with water and add ice until water reaches desired temperature.**
- 14. Start the experiment with 37.5 degree intake water.**
- 15. Wait for the temperatures of both rooms to reach about 110 degrees Fahrenheit before turning on the radiator fan and the pump.**
- 16. Record the temperature every 15 seconds until reaches a stable temperature (around 9 minutes later). Use USB temperature probes and a laptop computer if possible.**
- 17. Do this three times and record the data for each trial.**
- 18. Repeat steps 15 through 18 for 42.5, 50, 60, and then 70 degree intake water.**
- 19. When finished, transfer data onto a spreadsheet to assist with averaging the data for each trial.**
- 20. Create a chart using the data entered on the spreadsheet.**

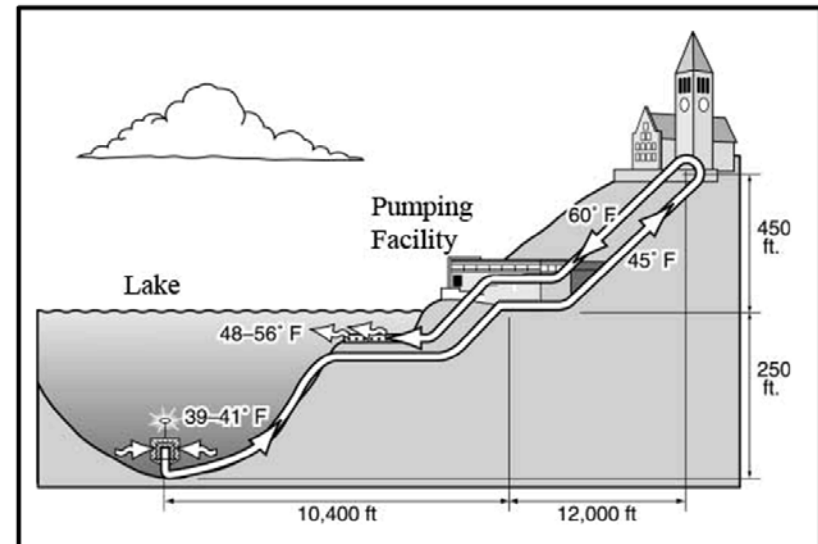
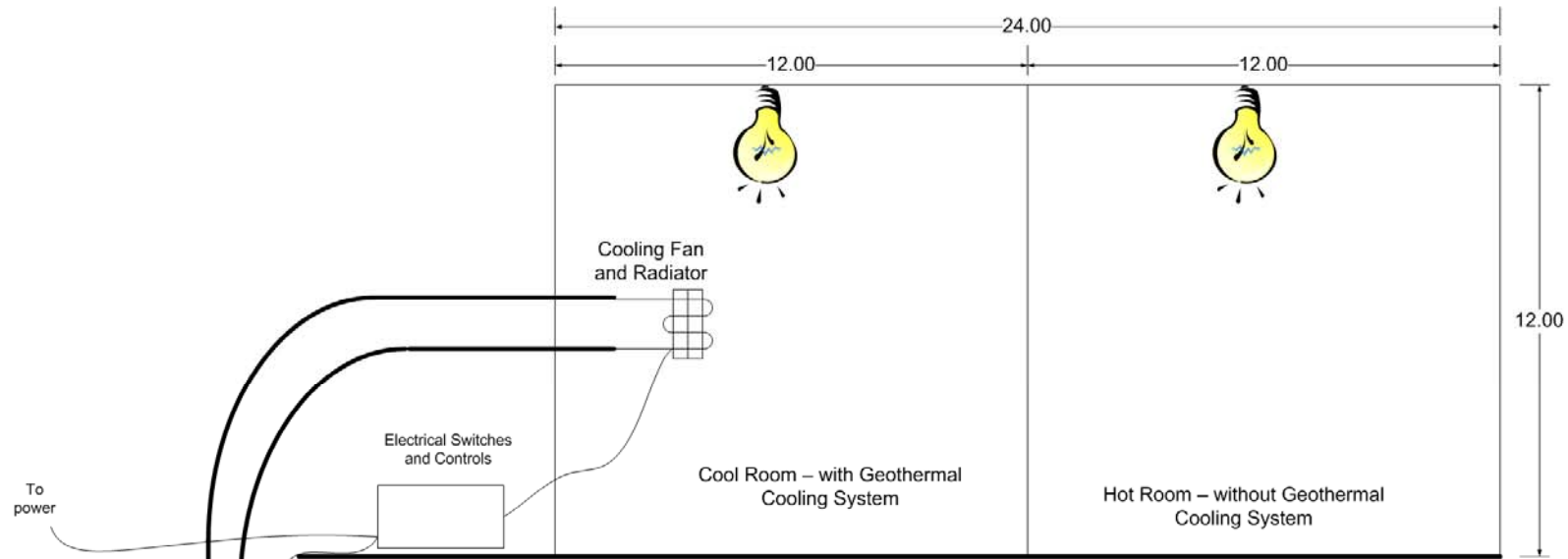
Geothermal: Lake Water Temperature Impact On Cooling



Data Collection (3 Trials)

Time	37.5 degree water				42.5 degree water				50 degree water				60 degree water				70 degree water			
	Trial 1	Trial 2	Trial 3	Average	Trial 1	Trial 2	Trial 3	Average	Trial 1	Trial 2	Trial 3	Average	Trial 1	Trial 2	Trial 3	Average	Trial 1	Trial 2	Trial 3	Average
0:15	109.50	110.45	111.01	110.32	109.94	110.29	109.83	110.02	110.51	109.34	110.25	110.03	111.01	111.24	110.89	111.05	111.12	110.30	110.09	110.50
0:30	107.78	107.87	107.21	107.62	109.94	110.01	110.15	110.03	109.27	108.80	109.32	109.13	110.52	109.31	110.70	110.18	109.82	110.10	109.68	109.87
0:45	105.89	105.49	105.68	105.68	106.91	106.89	106.61	106.80	101.51	101.93	101.84	101.76	106.68	106.37	107.05	106.70	106.12	106.31	106.61	106.35
1:00	100.94	101.36	100.75	101.02	102.52	102.99	102.68	102.73	97.01	97.29	96.53	96.94	99.71	100.02	99.73	99.82	99.71	99.91	100.17	99.93
1:15	94.64	94.69	94.32	94.55	95.99	95.97	95.80	95.92	90.59	90.56	91.09	90.74	98.13	98.21	98.17	98.17	99.71	99.23	99.93	99.62
1:30	87.78	88.27	87.41	87.82	89.02	88.85	88.65	88.84	86.54	86.49	86.52	86.51	94.42	94.75	94.08	94.42	96.56	96.39	96.12	96.36
1:45	83.28	83.74	83.28	83.43	84.41	84.38	84.37	84.39	82.27	82.39	82.33	82.33	91.72	91.68	92.11	91.83	93.86	93.68	94.19	93.91
2:00	78.67	78.37	78.45	78.50	80.24	80.34	80.17	80.25	79.57	79.26	79.32	79.38	88.79	88.50	89.12	88.80	92.06	92.30	91.72	92.03
2:15	75.97	75.91	76.11	76.00	76.19	76.11	76.31	76.21	77.54	77.37	77.70	77.53	86.88	86.74	87.11	86.91	90.71	90.96	90.31	90.66
2:30	73.16	72.92	73.17	73.08	74.84	75.14	75.22	75.07	75.29	75.41	75.45	75.38	85.08	85.46	84.78	85.11	88.79	88.70	88.84	88.78
2:45	70.57	70.75	71.06	70.80	72.48	72.20	72.55	72.41	73.61	73.48	73.32	73.47	83.62	83.66	84.07	83.78	87.78	87.97	87.58	87.78
3:00	68.54	68.82	68.12	68.49	70.79	70.81	71.07	70.89	70.79	70.92	70.83	70.85	82.04	81.88	82.40	82.11	86.66	86.30	86.21	86.39
3:15	66.52	66.85	66.60	66.66	68.54	68.62	68.13	68.43	70.79	70.44	70.47	70.57	80.58	80.27	80.76	80.54	85.76	85.61	85.88	85.75
3:30	65.28	64.87	65.48	65.21	67.53	67.33	67.88	67.58	70.34	69.98	70.73	70.35	80.13	80.16	80.50	80.26	85.31	85.16	85.37	85.28
3:45	63.03	62.78	62.79	62.87	66.52	66.90	66.68	66.70	69.33	69.20	69.70	69.41	79.01	79.01	79.17	79.06	84.41	84.79	83.95	84.38
4:00	63.03	62.58	62.92	62.84	65.62	65.32	65.62	65.52	68.54	68.37	68.07	68.33	78.22	77.72	78.69	78.21	83.51	83.55	83.51	83.52
4:15	62.36	62.75	62.61	62.57	64.94	65.28	64.94	65.05	67.98	68.27	68.25	68.17	77.77	77.68	77.97	77.81	83.51	83.62	83.65	83.59
4:30	61.34	60.84	60.95	61.04	63.93	63.96	63.60	63.83	67.42	67.52	67.43	67.46	76.87	76.38	76.57	76.61	82.83	82.34	82.75	82.64
4:45	60.78	60.81	60.70	60.76	63.03	62.63	63.28	62.98	66.74	66.55	66.43	66.57	76.08	75.59	76.03	75.90	82.49	82.74	82.56	82.60
5:00	60.22	59.73	60.06	60.00	63.03	63.02	63.20	63.08	65.96	66.41	65.63	66.00	76.08	75.94	76.03	76.01	81.82	82.15	81.39	81.79
5:15	59.43	59.74	59.08	59.42	63.03	63.10	63.47	63.20	65.39	65.01	65.75	65.38	75.63	76.02	75.24	75.63	81.48	81.59	80.99	81.35
5:30	58.87	59.31	58.84	59.01	63.03	63.36	63.36	63.25	65.39	65.69	65.74	65.61	75.18	75.56	74.79	75.18	80.47	80.42	80.66	80.52
5:45	58.87	58.57	58.51	58.65	62.58	62.63	62.74	62.65	64.83	65.05	65.00	64.96	74.96	75.15	75.18	75.10	80.58	80.53	80.32	80.48
6:00	58.31	58.39	58.43	58.38	62.36	62.49	62.84	62.56	64.49	64.21	64.07	64.25	74.39	74.07	73.93	74.13	80.58	80.42	80.20	80.40
6:15	57.86	57.53	57.73	57.71	62.13	62.35	61.91	62.13	64.49	64.51	64.78	64.59	74.17	74.55	73.71	74.14	80.47	80.93	80.72	80.71
6:30	57.74	57.91	57.60	57.75	61.91	61.90	61.62	61.81	64.04	63.91	63.77	63.91	74.17	73.78	74.33	74.09	80.58	80.53	80.56	80.56
6:45	57.41	57.00	57.52	57.31	61.68	61.28	61.93	61.63	63.82	64.04	63.56	63.81	74.06	73.93	74.48	74.16	80.47	80.61	80.76	80.61
7:00	56.96	56.66	57.10	56.91	61.57	61.19	61.54	61.43	63.48	63.65	63.29	63.47	73.72	73.71	73.66	73.70	80.58	80.65	80.46	80.56
7:15	56.62	56.16	56.41	56.40	61.46	61.30	61.79	61.52	63.14	62.83	63.20	63.06	73.49	73.39	73.15	73.34	80.47	80.03	80.95	80.48
7:30	55.94	55.53	55.81	55.76	61.23	60.73	61.65	61.21	63.14	63.08	63.31	63.17	73.38	73.53	73.15	73.35	80.47	80.41	80.25	80.38
7:45	55.72	56.05	55.35	55.70	61.23	61.65	61.72	61.53	63.14	63.10	62.96	63.07	73.04	73.05	73.42	73.17	80.47	80.35	80.31	80.38
8:00	55.72	55.57	55.65	55.65	61.12	61.33	61.23	61.23	63.14	63.11	63.00	63.08	73.04	73.44	73.34	73.27	80.24	80.13	80.46	80.28
8:15	55.72	55.28	56.06	55.69	61.12	61.17	61.09	61.13	63.14	62.87	63.52	63.18	73.04	73.40	73.23	73.22	80.02	80.46	79.64	80.04
8:30	55.72	55.54	55.50	55.59	61.12	60.97	61.38	61.16	63.14	63.14	63.46	63.25	73.04	72.64	72.95	72.88	80.02	80.48	79.94	80.15
8:45	55.72	55.47	55.85	55.68	61.12	61.56	60.98	61.22	63.14	62.96	62.79	62.96	72.93	72.90	73.15	72.99	80.02	79.79	79.91	79.91
9:00	55.72	55.83	55.62	55.72	61.23	60.78	61.40	61.14	63.11	62.68	63.37	63.05	72.71	73.04	73.01	72.92	79.91	79.80	79.44	79.72

Geothermal Cooling System Plan



Constructing And Using The Geothermal Cooling System



Cutting Boards for the Experiment Case



Staining the Experiment Case



Screwing in Base for Radiator and Fan



Completed System



Recording Water Temperature



Recording Cooled Room Temperature Data



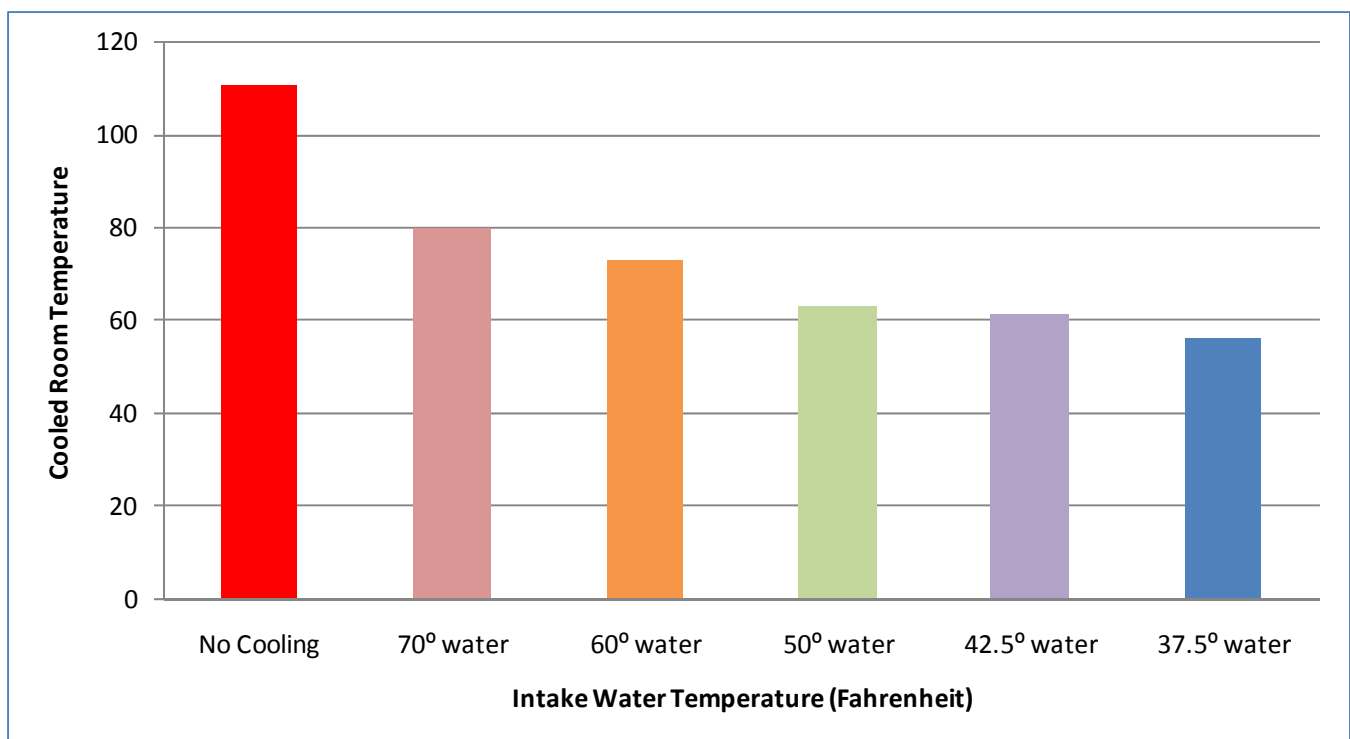
Reasons for Error:

- 1. The USB temperature probes were very inexpensive and may not be calibrated exactly the same.**
- 2. The light bulbs in the control and cooled room may have put out different amounts of heat.**
- 3. Because of the heat returned to the water during the cooling process, each trial could have had slightly different starting temperatures.**

Conclusion:

My hypothesis was supported. The intake water from the deeper depths (lower temperature water) cooled the room more than the water from the shallower depths (warmer water).

The chart below shows the cooled room temperature at various intake water temperatures.





Post Project Thoughts:

1. Overall the project was fun but took more time than I thought.
2. I learned that the colder intake water cooled the room more.
3. We first started out using 60 watt bulbs, but they didn't produce enough heat. The 100 watt bulbs got the rooms to over 110 degrees Fahrenheit.
4. We bought USB temperature probes to use during the experiment. This made collecting the data easy using my laptop.
5. Next summer, I would like to visit Cornell University in Ithaca, New York where they have a large geothermal cooling system similar to my model.